Jun 28th, 9:00 AM

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Citation

Fleischmann, K.(2013) Integrating multidisciplinary collaboration in undergraduate design education: Too many cooks spoil the broth?, in Reitan, J.B., Lloyd, P., Bohemia, E., Nielsen, L.M., Digranes, I., & Lutnæs, E. (eds.), *DRS // Cumulus: Design Learning for Tomorrow*, 14-17 May, Oslo, Norway. https://doi.org/10.21606/learnxdesign.2013.046

DRS // CUMULUS 2013
2nd International Conference for Design Education Researchers
Oslo, 14–17 May 2013

Integrating multidisciplinary collaboration in undergraduate design education: Too many cooks spoil the broth?

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Abstract: *Employability studies continue to highlight the fact that digital media design graduates may not be sufficiently prepared to bridge the gap between university and industry. In response, an alternative learning and teaching approach for digital media design education, the POOL Model framework, was developed and subsequently trialled at an Australian university. A broad underpinning strategy of the framework is to reflect industry practice through implementing workplace realities such as multidisciplinary teamwork. Introducing multidisciplinary collaborative practice into design education is identified as necessary; however, exactly how these collaborations can be managed at an undergraduate level is less well defined. This paper describes the design of a collaboration that engages undergraduate digital media design students in multidisciplinary teamwork with information technology students and subsequently multimedia journalism students as well. Can such multidisciplinary collaborations be beneficial for all participating students? Are there too many disciplines involved? Challenges that commonly occur when undergraduate design students engage in multidisciplinary collaborations with disciplines outside the creative arts were identified. These informed the development of strategies (pragmatic principles) which aim to facilitate the functioning of the POOL Model framework and the development of a sustainable solution. Findings from a three-year study are presented.*

Keywords: multidisciplinary undergraduate design education, POOL Model framework, multidisciplinary collaboration.

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Introduction

Designers today and increasingly in the future need to be able to navigate within a shifting economic, social, cultural and technological landscape. Design and communication problems become increasingly complex, are often part of larger systems and have at times a global scale and audience. According to Barnes-Powell (2008), the "two momentum trends of this century are growing complexity and increasing rates of change" (p. 378). This situation is challenging for designers because in this "complex, changing professional environment…design involves more skills and knowledge than one designer can hope to provide, [in fact] most successful design solutions require several kinds of expertise" (Friedman 2000, p. 21). Consequently, work environments that are based around multidisciplinary, interdisciplinary or transdisciplinary models are seen as providing fruitful ground to respond to the increasing complexity. In fact, the digital media design industry (e.g. interactive media design, game design) is structured around multidisciplinary teamwork, with designers mostly working in collaborative environments (Kerlow 2001; Niederhelman2001; Sommese 2007; Whyte and Bessant 2007). This reality, however, is rarely reflected in digital media design education. Bennett (2009) argues that "despite numerous isolated examples of innovative practical pedagogical projects taking place worldwide, there are still no proposed working models…that are specifically aimed at assisting visual practitioners to work collaboratively" (p. 5). A study undertaken in Australia revealed that only 27% of the 120 surveyed university design students (diverse levels and areas, e.g. multimedia design, industrial design) had the opportunity to work with students from other disciplines (Design Victoria 2009). While this research is Australia-specific and a small sample, it is alarming evidence and arguably indicative of many design degree programs worldwide (e.g. Szenasy 2004, Design Council and Creative & Cultural Skills 2007).

The current debate on the future of design education highlights the fact that changes are urgently needed (see i.e. Icograda 2011, Visible Language 2012). In fact, some design educators and practitioners argue that design education is stuck in the past (e.g. Davis 2011, Norman 2011, Poggenpohl 2012), "out of date" (Dubberly 2011, p. 81) and seemingly incapable of meeting the demands of the changed scope of the profession and the marketplace (Canniffe 2011). Employability studies reinforce this argument, revealing that digital media design graduates may not be sufficiently prepared for the workplace (Design Council 2005, 2010; 60Sox 2009, 2010; ISIS 2011). In particular, a lack of teamwork skills are often identified in design graduates (Ball 2003; Design Council and Creative & Cultural Skills 2007; 60Sox 2010). Ball (2003) argues that most design students experience collaborative teamwork only with other design students, which leads to a "lack of critical team-working to mirror industry practice" (p.18). This is surprising because design educators seem to have a positive view on collaboration across other disciplines. Szenasy (2004) discovered when surveying 325 North American design educators that 71% "completely agree" and 24% "somewhat agree" that interdepartmental collaborations are an important part of the curriculum. A similar situation was found in Australia, where surveyed design educators were aware of some criticism and nearly half of the surveyed institutions intended to implement improvements by increasing opportunities for interdisciplinary collaboration for students (Design Victoria 2009).

Although progress appears to be slow, the process of re-thinking design education has begun. Davis (2011) acknowledges that a few programs "demonstrate foresight by

addressing the shifting landscape of design practice" (p. 73). Some examples include the d.schools, founded by Hasso Plattner Institute at Stanford University and in Potsdam, the Master in Multidisciplinary Design Innovation at Northumbria University and the Master of Fine Arts in Transdisciplinary Design introduced by Parsons The New School for Design. These programs have certain aspects in common: they are newly founded programs (rather than a re-design of an existing program); they are still relatively unique compared to the number of design schools in existence worldwide and they are all offered at postgraduate level. In fact, when overviewing the latest efforts to base design education programs in part or completely on collaborative practice it becomes evident that even fewer approaches are introduced at undergraduate level. Although some examples exist, collaborations, particularly those with disciplines outside the creative arts, often appear to be sporadic if they occur at all.

This picture gives rise to several questions. Are undergraduate design students not ready to engage with disciplines outside the creative arts? Are multidisciplinary collaborations not considered beneficial at this level? Is it too difficult? Is it too expensive? Why is it that, on one hand, working collaboratively is identified as essential and fundamental to learning (Heller and Talarico 2011), and as a key skill required for the future (Hunt 2011), and on the other hand, particularly in the area of digital media design where the complexity of projects clearly requires different disciplinary input to produce an outcome, an approach that is reflective of such reality is still missing in undergraduate design education? Certainly, issues such as silo mentalities, university structures and time constraints are recognised as barriers to interdepartmental collaboration (e.g. Szenasy 2004, Design Council and Creative & Cultural Skills 2007, Canniffe 2011). But are there other reasons? In order to obtain a deeper understanding of this complex situation, investigations were made to determine whether common challenges could be identified and subsequently evaluated to establish whether these challenges could be effectively managed to facilitate the implementation of a sustainable approach to multidisciplinary design education at undergraduate level.

Multidisciplinary collaboration: The POOL Model framework

In response to the identified shortfalls in design education and to better prepare undergraduate digital media design students for professional practice in the creative industries, an alternative learning and teaching approach was developed. The *POOL Model framework* consists of a teaching pool and a learning pool containing specialists from diverse but connected disciplines. In the *teaching pool,* educators work collaboratively to define a project or problem and create a learning environment for students to develop the project or respond to the problem in multidisciplinary teams. People external to the university are included in the teaching pool, such as industry professionals, and the community—arguably a pool in itself—in the capacity of clients, advisors, experts or sponsors. In an ideal environment, the input into the teaching pool can also occur inter-institutionally, depending on the project/problem definition and resources needed. This would have a significant impact on the sharing of key knowledge between institutions and would require a major shift in current thinking.

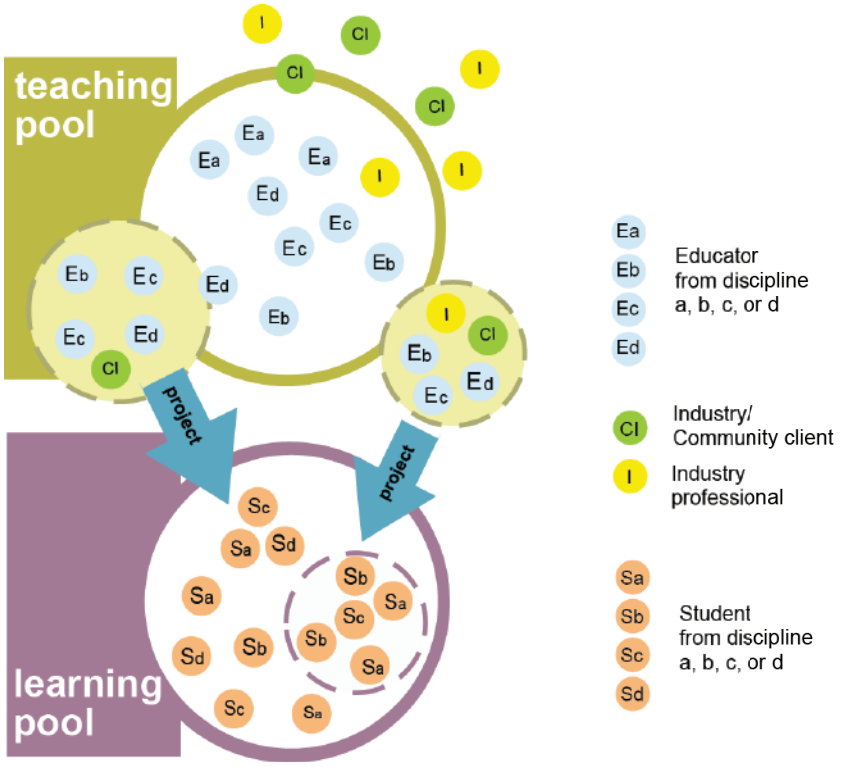

Figure 1. The POOL Model framework: an alternative learning and teaching approach for digital media design education.

In the *learning pool*, students from different disciplines form teams to solve a defined problem or produce a project collaboratively. The composition of the team will depend upon the presented problem/project. While working in these collaborative multidisciplinary teams, a student will be able to gain insights into, and develop an understanding of, other disciplines. Through the collaborative multidisciplinary team approach and the shared learning process, each student will have additional time to concentrate upon discipline-specific skill development and challenges within his/her multidisciplinary team while experiencing a more holistic and efficient way to approach complex projects or problems. Figure 1 provides a graphical illustration of the POOL Model framework.

The POOL Model framework was implemented in three subjects in the curriculum of the digital media design major in the Bachelor of New Media Arts degree. One of these subjects was Web Authoring 1 (School of Creative Arts), which was offered jointly with the subject Multimedia Web Design (School of Business, discipline IT) to facilitate industry-relevant collaborations between undergraduate digital media design and IT students. Both subjects were 2nd year introductory subjects on web design and web development, with Web Authoring 1 focusing on the design and basic development of websites and Multimedia Web Design on web development (backend). Both subjects had been taught separately up to this point. The collaboration between digital media

design and IT students was trialled in 2009 for the first time. A community client was involved in providing a real world project for students to work on, which was also the case in 2010 and 2011.

Due to the School of Creative Arts proactively looking for additional disciplines to participate in the collaboration, multimedia journalism students from the newly introduced Bachelor of Multimedia Journalism course joined the learning pool in 2010 (see Appendix A for numbers of participants in 2009-2011). While collaborative practice is identified as one way forward in the current debate on the future of design education, on the other hand, the exact way in which such collaborations are managed on the ground is less well defined, particularly in undergraduate design education.

Challenges to overcome

Although recently the number of innovative approaches to design education has increased, it is notable that there is a lack of published data measuring their impact and efficiency (Design Council 2010). From the limited number of published examples from undergraduate design education, only a few have applied research methods such as surveying or interviewing students to evaluate the approach. Examples that aim to mirror industry practice with cross-disciplinary production teams being established when producing games or animations (Ebert and Bailey 2000; McDonald and Wolfe 2008) exist and were analysed. Due to the lack of relevant research relating to undergraduate digital media design education, examples from the area of industrial design (also known as product design) were also included. This is because some authors, for example; Viemeister (2001), Stone (2004) and Talbot (2007), make references to similarities between industrial design and digital media design in that both have a comparable product development and user testing process, and both have the need to deal with increasing complexities through new emerging digital technologies (Choi 2009) (see Appendix B for the list of examples analysed).

Table 1 overviews the challenges outlined by the authors and also displays details of the disciplines collaborating and student numbers, if available. All collaborations analysed were conducted in undergraduate degree programs in North American institutions.

Table 1. Challenges identified by design educators when engaging undergraduate art and design students in multidisciplinary collaborations that reflect industry practice.

	Disciplines No. of teams/size/no. of students / Duration	**Challenges**
1	- art students, computer science - four to five students per team - 12 weeks	- it does require a significant amount of effort in teaching not only computer animation, but teaching successful teamwork and group dynamic techniques.
2	- computer science, fine arts, (music composition students were brought in during class) - four to five teams/ five to six students per team	- students were given a free choice of roles to perform (coding or design), which resulted in an environment that did not accurately mimic a commercial production environment; - some students undertook roles they were not adequately prepared for and that element was left incomplete or was implemented poorly; - the concept of critiques was not familiar to the computer science students.
3	- art, design, computer programming, business - three groups: programming, writing and art group; 27 students - 16 weeks	- ongoing tensions between these groups throughout the course; - differences in subject culture: design and computer science are very different from each other, not only in subject content, but in styles of discourse.
4	- industrial design, graphic design, business (marketing, finance) - three teams; 16 students - 16 weeks	- discomfort with the 'messiness' and ambiguity of the project development process, which intentionally was designed to reflect the real world; - different subject culture; - considerable time was spent in the teams explaining and clarifying basic terms and/or ideas; - business and design students possessed very different ideas about basic development methodologies; - majority of students had underestimated the huge time demands of cross-functional teamwork.
5	- industrial design, business, mechanical engineering - 11 teams (in two years)/six to - seven students per team, two from each discipline; 34 students	- teamwork caused conflict, frictions among team members, *team dynamics do matter;* - individual team members did not deliver their agreed-upon deliverables on time, causing difficulty for the entire team.
6	- industrial design, business - two design students and four business students per team; 45 students - ten weeks	- uncomfortable ambiguity and team conflicts; - students felt pressure of tackling an open-ended and undefined problem with team-mates who did not share similar training, work styles, personal objectives, etc.; - workload conflict; - business students were completely unfamiliar with the ways in which design students work.
7	- product design, business, engineering - three to nine students per team - six to nine months	- teamwork is difficult, especially when different disciplines are involved; - alignment and realisation of individual and team goals; - subjects culturally different, e.g. discussing something openly is not common in engineering culture, or meeting in the lab three days a week for two hours of class time is common in design but not in engineering or business.

Although Table 1 presents only a small number of examples, it is evident that similar challenges have been identified in all studies. A recurring theme is that difficulties in teamwork are caused by collaboration between students with different disciplinary cultures or subject cultures; hence, with a diverse "community of practice" (Wenger 2006). These disciplines have different work methods, different learning approaches and different ways of completing projects. Fry (2006) highlights the fact that "philosophies underlying their respective disciplines regarding modes of creativity are often at odds with one another. This encourages conflict and frustration".

Findings from research conducted with design educators from eighteen Australian universities, reported elsewhere in detail (Fleischmann 2010), identified the following student collaboration challenges presented in Table 2:

Table 2. Student collaboration challenges identified by Australian design educators in face-to-face interviews.

	Challenges
Skills	- matching skill levels of the technical understanding and competence of students from different distinct academic areas.
Interpersonal skills	- common language missing; - communication in all forms; and - the notion of collaboration is little understood.
Assessment	- structural problems, especially with assessment – each discipline has specific requirements to ensure teaching and learning aims are met.

Findings presented in Table 1 and Table 2 indicate a range of challenges that appear to be common when design students engage in multidisciplinary collaborations. Key challenges appear on various levels; some are linked to different skill levels and difficulties arising through different discipline cultures and others relate to the management of teamwork and assessment procedures. What is interesting, however, is that the identified issues are essentially pragmatic, rather than reflecting fundamental curricular, or unsolvable pedagogic, challenges. Therefore, the attempt can be made to develop supporting strategies to help manage these challenges and ultimately prevent them from occurring.

Enabling multidisciplinary collaboration

Based on the findings presented above, supporting strategies to manage multidisciplinary collaboration effectively and thereby support the functioning of the POOL Model framework were developed. This meant looking at what could be done to eliminate challenges. Table 3 outlines key areas in which challenges occur, the identified challenges (synthesised from Table 1 and Table 2) and implications (actions to be undertaken).

Table 3. Managing challenges in multidisciplinary collaborations.

What needs to be addressed at a pragmatic level?		
Key area of relevance	Challenges identified	Implications
Skills and understanding of discipline	- different skill levels of participating students - a lack of understanding and/or appreciation of the other disciplines	- align learning outcomes of each participating discipline - build a shared learning environment that also allows the development of discipline-specific skills and their application to a collaborative outcome - specify joint and discipline-specific learning outcomes - educate students regarding the contribution of each participating discipline to the collaborative process in order to create an understanding of their value in the process
Work ethic/ Equal work load	- different work ethics amongst students regardless of discipline - different learning styles amongst students regardless of discipline - different levels of motivation amongst students regardless of discipline	- monitor and organise teamwork and collaborative interactions - formal teaching on teamwork, conflict resolution, etc. needs to be part of the learning environment - integrate teamwork exercises (e.g. ice breaker)/ communication exercises if disciplines have different discipline culture (e.g. IT and Design) and/or students are not known to each other
Communication/ Collaboration	- different disciplinary cultures lead to difficulties in communication - missing knowledge on effective collaboration amongst students regardless of disciplines	
Assessment	- assessment of different disciplines participating in collaboration - co-ordinate assessment between disciplines - fair assessment of individual performance in teamwork	- identify assessable joint and discipline-specific tasks (outcome) and teamwork related (process) assessment items - include peer and self assessment

While the POOL Model framework presents a 'big picture' approach to digital media design education, more detailed pragmatics were developed to reflect the implications identified in Table 3, such as the integration of formal teaching regarding effective teamwork, the building of a shared understanding of the collaborative teamwork process, support for discipline-specific skill and knowledge development and assessment mechanisms to evidence and support learning. Figure 2 shows how learning and assessment are managed within the POOL Model framework (pragmatic principles), using two disciplines as an example of how this approach works in practice.

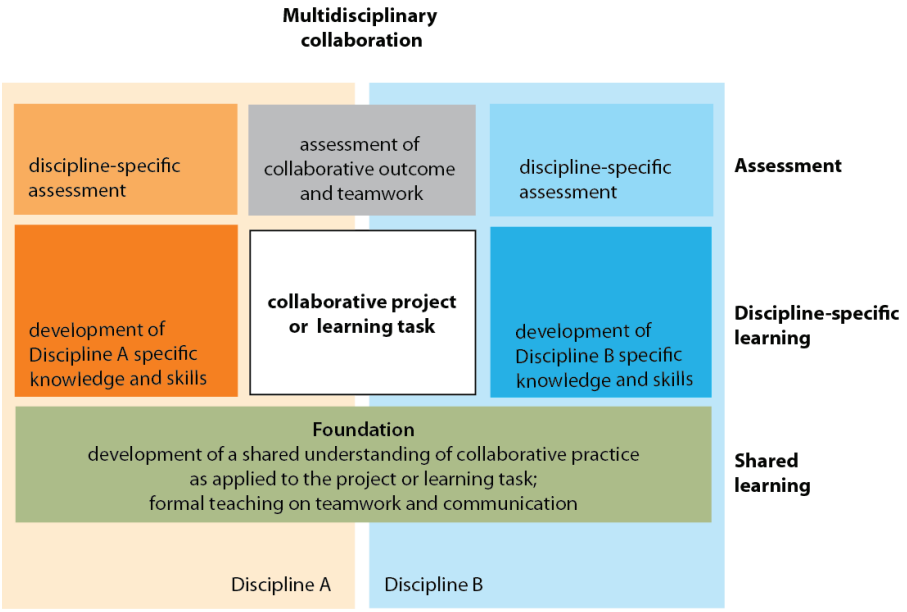

Figure 2. Pragmatic principles: managing multidisciplinary collaboration within the POOL Model framework.

These pragmatic principles were translated into a study plan for two disciplines initially (digital media design and IT), as shown in Table 4. The table overviews the specifics of the collaboration, showing details of the structure of the curriculum delivered and the activities that took place across the 13-week semester.

In order to expose students to realistic (authentic) challenges, students took on roles equivalent to those existing in the industry, as either IT developer or interface designer (2009-2010). To also integrate multimedia journalism students effectively into the multidisciplinary collaboration, the developed pragmatic principles needed to be expanded to include these students, starting in 2011. Therefore, the role of a multimedia journalist within a real world Web design team environment, for example, needed consideration. After seeking input from the Head of Journalism, an additional role within the multidisciplinary collaboration was created to cater for the workplace requirements of journalists. Discipline-specific lectures and workshops for multimedia journalism students were added and delivered by a journalism educator. This also included the assessment of this student group to be undertaken by the journalism educator. In order to build empathy and understanding across all disciplines, a lecture on Writing for the Web was delivered to all students. As a result, the project team had become an even more realistic reflection of industry practice.

Table 4. Curriculum plan and structure for multidisciplinary collaboration between digital media design and IT students 2009-2010.

<table>
<tr><th>Week</th><th>POOL Model framework core characteristics/ pragmatic principles</th><th>Discipline Digital media design</th><th>Discipline IT</th><th colspan="2">Learning outcomes shared</th></tr>
<tr><td>1-5</td><td>Shared understanding

Web design industry professional as tutor to deliver up-to-date and industry relevant knowledge</td><td colspan="2">- lectures delivered by either IT or digital media design educator to both student groups to build common knowledge base and develop understanding for other discipline
- team-taught lectures to expose students of both disciplines to interrelating disciplinary views on presented problem
- learn how to design and develop a simple website, individual work</td><td colspan="2" rowspan="2">- elementary understanding of how to design and develop a basic website
- produce a professional website
- develop an understanding of how the two disciplines work together on website projects
- understand and acknowledge each discipline's contribution to the project development process
- document website development for further use/ extension (e.g. create production document, style guide)
- develop team working and communication skills</td></tr>
<tr><td>6</td><td>Teamwork preparation</td><td colspan="2">- lecture on teamwork (team-taught)
- practical icebreaker exercise (getting to know the other discipline)
- team forming</td></tr>
<tr><td rowspan="3">7-12</td><td>Discipline-specific knowledge/skills</td><td>Discipline-specific lectures delivered by design educator to digital media design students</td><td>Discipline-specific lectures delivered by IT educator to IT students</td><td>Learning outcomes for digital media design students:</td><td>Learning outcomes for IT students:</td></tr>
<tr><td>Community client provides project

Teamwork</td><td colspan="2">- collaborative project; client briefing
- weekly tutorial time is used to provide feedback from IT and design educators on project development process, indicating sources for self-directed learning, monitor teamwork, resolve teamwork issues and disputes</td><td rowspan="2">- create an information architecture and translate it into a functional user friendly navigation and interface design
- produce images, graphics and animation according to</td><td rowspan="2">- learn to use markup languages and style sheets and work with dynamic functionalities (PHP & database) for creating a website
- become proficient in technical aspects of web</td></tr>
<tr><td>Web design industry professional as guest lecturer and advisor</td><td colspan="2">- presentation of prototype to web design industry professional, feedback</td></tr>
</table>

13	Community client	- presentation of project to client - feedback from client and educators provided	technical requirements of the screen-based online environment	development, such as code validation, accessibility and usability issues

Methodology and research design

The presented study is part of a larger doctoral research project which is framed by a pragmatic approach. This allowed the researcher to choose methods that suit the real-world practice nature of the situation (Creswell 2003; Johnson and Onwuegbuzie 2004; Punch 2009). A parallel mixed methods research design was applied. Online questionnaires were used to collect quantitative and qualitative data from students in addition to focus group interviews (collecting qualitative data). This allowed for the triangulation of data obtained through different methods, providing corroborating evidence for the conclusions drawn, i.e. validation technique (Bazeley 2004; Johnson and Christensen 2008; Teddlie and Tashakkori 2009). Feedback was also obtained from educators involved, allowing further triangulation, of different data sources which would add depth and/or breadth to the study through "expression of different facets of knowledge or experience" (Bazeley 2004, p. 4). Although an in-depth qualitative data analysis was conducted on feedback received from students and educators, the scope of this paper requires a focus on quantitative findings primarily. Some qualitative feedback is used in this paper "to enrich the bare bones of statistical results" (Rossmann and Wilson 1985 p.636) and to illustrate the situation (Fielding 2012).

The following questions were explored to evaluate the effectiveness of the pragmatic principles supporting the multidisciplinary collaborative teamwork process:

- Was the multidisciplinary collaborative teamwork considered beneficial?
- Did students develop an understanding of the multidisciplinary collaborative teamwork process?
- Did each disciplinary group have the opportunity to concentrate on their own area of expertise while being part of a multidisciplinary team?

Findings and discussion

Table 5 presents quantitative feedback from students in regard to the effectiveness of the POOL Model framework and its implemented pragmatic principles over a period of three years. Findings are presented for each participating discipline group per year and a 3-year average is presented in the last column.

The 3-year average gives an indication of the overall positive outcome across all disciplines. Looking specifically at disciplinary groups, a high percentage of students in each group believed the multidisciplinary collaboration to be beneficial. Only 19 from a total of 198 students (8%) across three years thought that this was not the case. The students' reflection on their ability to develop an understanding of the multidisciplinary teamwork process was similarly positive, with only 18 of the 198 students (8%) stating that they were unable to develop such understanding. The feedback from students of all discipline groups has shown significant support for working in multidisciplinary teams.

Table 5. Students' perspectives on multidisciplinary collaboration 2009-2011.

		2009		2010			2011			3-year average
Discipline (2nd year undergraduate)		IT	DMD	IT	DMD	MMJ	IT	DMD	MMJ	
Did your project benefit from working in a multidisciplinary team?	Yes	100% (24)	95% (19)	86% (25)	88% (28)	100% (4)	79% (23)	91% (42)	100% (14)	92%
	No	0% (0)	5% (1)	14% (4)	12% (4)	0% (0)	21% (6)	9% (4)	0% (0)	8%
Do you think that you have developed a better understanding of how people from IT and Design can work together on such projects?	Yes	100% (24)	100% (20)	86% (25)	91% (29)	100% (4)	83% (24)	94% (43)	79% (11)	92%
	No	0% (0)	0% (0)	14% (4)	9% (3)	0% (0)	17% (5)	6% (3)	21% (3)	8%
Do you feel that you could explore and concentrate on your area of expertise while being part of the multidisciplinary team?	Yes	92% (22)	90% (18)	93% (27)	78% (25)	50% (2)	86% (25)	76% (35)	93% (13)	82%
	No	8% (2)	10% (2)	7% (2)	22% (7)	50% (2)	14% (4)	24% (11)	7% (1)	18%
Number of student participants		24	20	29	32	4	29	46	14	
IT = Information technology, DMD = Digital media design, MMJ = Multimedia journalism										

When looking at each discipline and their ability to continue to develop discipline-specific skills, Table 5 shows that some students had difficulties with this aspect in the multidisciplinary collaborations. Digital media design students reported more problems with this than the other discipline groups, with a 3-year average of 19% of digital media design students (10% in 2009; 22% in 2010; 24% in 2011) stating that they were not able to continue to develop discipline-specific skills. The number of digital media design students who were able to concentrate on their area of expertise (81% across three years) is still relatively high and considered a positive outcome, especially considering the fact that these students had engaged in such multidisciplinary collaborations for the first time during their course of study when undertaking *Web Authoring 1*. Nevertheless, challenges that had prohibited a more positive outcome needed to be further investigated.

When exploring why 19% of digital media design students (20) across three years were unable to concentrate on their area of expertise while being part of a multidisciplinary team, the following factors emerged:

- some digital media design students worked in a self-chosen non-design role, which required exploring other areas;

- team problems were raised relating to different work ethics resulting in unequal workloads and communication problems;
- team members were reported as not being skilled enough or not doing what they were supposed to do, and therefore a student had to take over another discipline's part; and
- students' design work was not valued and/or another designer's idea was selected within the team.

It is notable that identified challenges do not directly relate to the different disciplines working together; rather, they can be identified as issues arguably occurring in any kind of group or teamwork. In the case of communication problems, they clearly related to teamwork or work ethics problems caused by individual students, as the following comment shows:

> There were a few communication issues, where some people would not respond or contact the team via the modes of contact they asked to use at the beginning of the project. This just made things difficult to plan. (Multimedia journalism student)

On the contrary, some students specifically mentioned the development of communication skills; one example from each discipline is presented in the following:

> We had to communicate really well, because they might not understand why we've designed the page in a certain way. And we might not understand why we can't do certain things because it needs to work out from the IT side of things. (Digital media design student)
>
> You get experience communicating with someone who isn't necessarily at the same level of knowledge as you are. So you've got to put things in a way that they can understand or figure out what they know before you just bombard them with information. (IT student)
>
> You've got to have really good communication because some team members might not understand your point of view so much. (Multimedia journalism student)

It needs to be noted that although assessment strategies were developed and are considered important in supporting the functioning of multidisciplinary collaborations in undergraduate design education, given that students view assessment as a key element of the learning experience, their effectiveness was not explored within the scope of this study. However, when analysing qualitative feedback from students, comments on assessment being "fair" or "unfair" did not emerge.

The overall positive feedback from students of all disciplines indicates that the pragmatic principles were effective. The feedback from the group of multimedia journalism students in particular best shows how the pragmatic principles worked in practice. Adding discipline-specific content (lectures and workshops) in 2011 for multimedia journalism students as well as including a journalism educator for the delivery of content and assessment had a positive effect, with 93% of the multimedia journalism students stating that they could concentrate on their area of expertise while participating in the multidisciplinary collaboration. In the previous year (with pragmatic principles applied for digital media design and IT students), only 50% of multimedia design students stated the same. It is acknowledged that the feedback received in 2010 was from a very small number of students (4) and generalisations could not be drawn. Nevertheless, the feedback was an early indicator that adding disciplines without specifically defining joint and discipline-specific learning outcomes and means of

assessing the discipline may inhibit the achievement of beneficial outcomes for those additional discipline groups. Ultimately, this led to the decision to apply the pragmatic principles to effectively integrate multimedia journalism students into the multidisciplinary collaboration, which resulted in a very positive outcome with only one multimedia journalism student (7%) reporting an inability to concentrate on his/her area of expertise while being part of the multidisciplinary team.

When exploring educators' perspectives on the structured approach to multidisciplinary collaboration, all educators involved during the three-year period reflected positively on it. The following comments from an IT educator provide some insight into the integration of the three diverse disciplines:

> We're doing quite well with design and IT together. We're seeing better results than we ever got in our separate disciplines. …That is because students understand that it's not just here's my bit and here's your bit, but here's us working together on it.
> My overall feeling is that we have more exceptional projects. I think our efforts in explaining how design, IT and journalism work together and how it is visible on a website paid off.
> Some of the journalism students created good content, and there were some excellent homepages with good blurbs that were well written. … I think they had that incentive of not being just thrown into a design subject, but put into a subject that has a relevant journalism aspect…

The effectiveness of formal activities, such as teaching on effective teamwork and communication, was explored with educators. They agreed that integrating these formal elements was valuable and, in fact, needed. One educator commented:

> Teamwork doesn't happen on its own. There is leadership involved and team organisation and you can't just all sit and wait for it to happen… We actually got them to write down methods of communication, plans for communicating properly… we didn't just put them in a group and hope they would work together. … In terms of communicating across, …there didn't seem to be too many communication problems between design and IT.

The journalism educator also highlighted the benefits of multidisciplinary collaboration and its relevance for students' employability:

> I see the skills offered in this subject as being highly beneficial for journalism students who are entering a changing media landscape where they may often be working in small teams... This subject engages students in team building and helps them realise how their journalism skills might be used. Some of our graduates end up working for small Web-based companies so this subject also helps them become more work ready. (Journalism educator)

In summary, the educators involved in this three-year trial considered multidisciplinary collaboration beneficial for students from each participating discipline. In fact, all educators would prefer this way of learning and teaching to continue in the future.

Conclusion

While there is a saying that too many cooks spoil the broth, the contrary is true for designers and their education. Multiple and diverse disciplines are required to formulate responses collaboratively for a world of increasing complexity and change. Design education must enable students to participate in multidisciplinary collaborative processes in their future work environment. The POOL Model framework was developed to better prepare digital media design students for a work environment in which they will be required to create and innovate with people who have work methods and a style of communication different from their own. A highly structured approach was developed to manage multidisciplinary collaboration at undergraduate level. The developed pragmatic principles (e.g. integrate teaching of teamwork skills, offer discipline-specific and shared learning content for each participating discipline) supported the majority of digital media design students and students from other disciplines in interacting with each other and helped them manage the multidisciplinary teamwork process effectively. Challenges that were identified as commonly occurring in multidisciplinary collaborations, and in particular when undergraduate design students engage with students from disciplines beyond the creative arts, have, to a large extent, been absent.

Because the POOL Model framework presents an industry-reflective approach to design education, and is dependent upon the nature of the project or problem, the learning and teaching pool can be expanded to include more disciplines. While this study looked at collaborations across three diverse disciplines, more research is needed to explore the effectiveness of the pragmatic principles when even more disciplines are involved.

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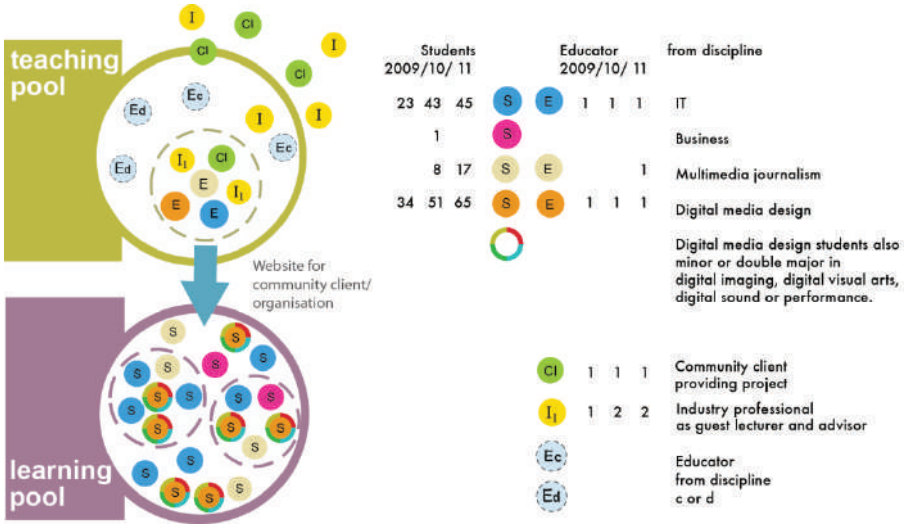
Appendices

Appendix A

POOL Model framework and participants in the collaborative subject offering during 2009-2011.



Appendix B

List of published examples from undergraduate design education analysed.

	Author
1	Ebert and Bailey 2000
2	Duesing and Hodgins 2004
3	Dickey 2010
4	Rothstein 2002a, 2002b
5	Melamed, Page and Scott 2004
6	Welsh, Murray and Privatera* 2005
7	Privitera and Zirger 2006
* This conference paper was published with a spelling error in the name of the third author. The correct spelling should be: Welsh, Murray, and Privitera.	